Review of Whole Sediment Toxicity Test Data From Baltimore Harbor

Presented by:

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Whole Sediment *Leptocheirus plumulosus* 10-d Acute Test Method

Top 2 cm of sediments from a number of grabs collected and homogenized

Sub samples taken for chemical analyses and toxicity tests

Sediments sieved to 500 µm to remove indigenous *L. plumulosus*

Temp - 25°C; Test beaker size – 1L with 2cm sediment and 800 mL overlying water

Test is static with aeration but without food

Organism size: sub adults (pass through 750 µm sieve onto 500 µm sieve)

Five replicates per station; 20 amphipods per replicate

Test termination – sediments sieved through 500 µm sieve, live amphipods counted

Endpoint: Survival

Performance criteria: Control survival ≥ 90%

Whole Sediment *Leptocheirus plumulosus* 28-d Chronic Test Method

Top 2 cm of sediments from a number of grabs collected and homogenized

Sub samples taken for chemical analyses and toxicity tests

Sediments sieved to 250 µm to remove indigenous *L. plumulosus*

Temp - 25°C; Test beaker size – 1L with 2cm sediment and 800 mL overlying water

Static renewal with aeration (overlying water renewed three times per week)

Organism size: Neonates (pass through 500 µm sieve onto 250 µm sieve)

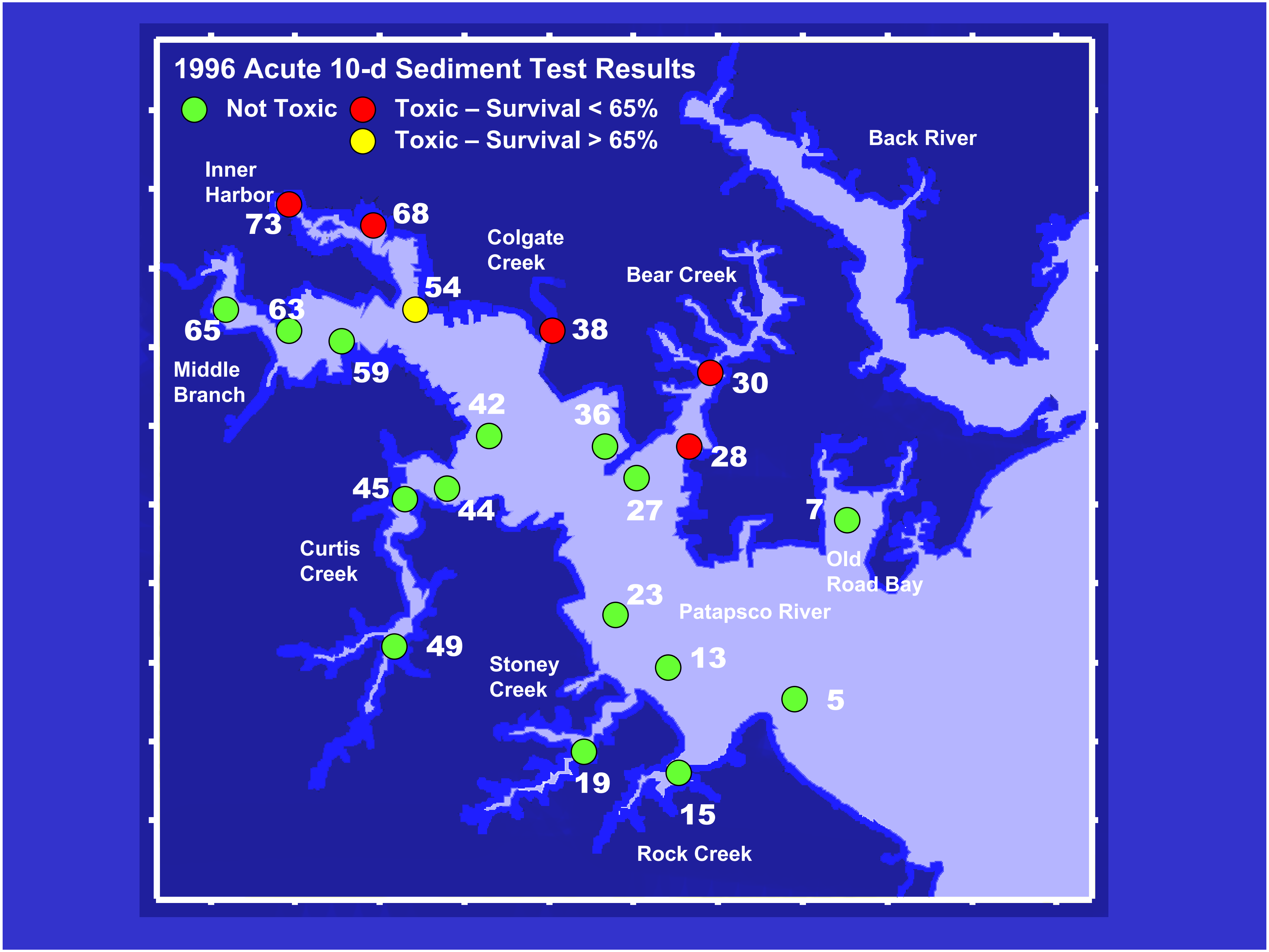
Five replicates per station; 20 amphipods per replicate

Organisms fed ground TetraMin three times per week when water renewed

Test termination – sediments sieved through 500 µm sieve, adult amphipods collected, dried and weighed; Neonates collected on 250 µm sieve, stained and fixed with Rose Bengal in ethanol for later counting

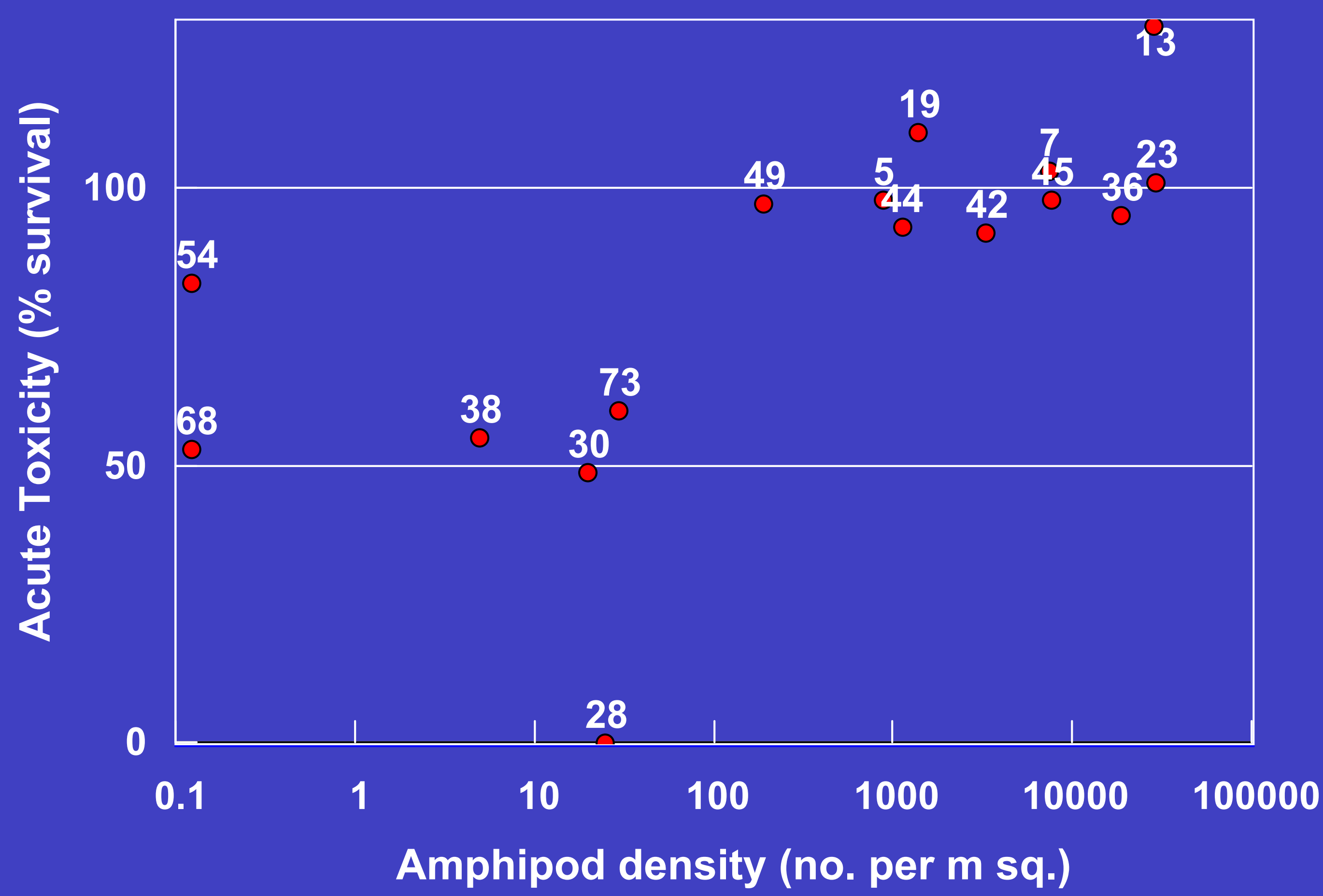
Endpoint: Survival, growth, and reproduction

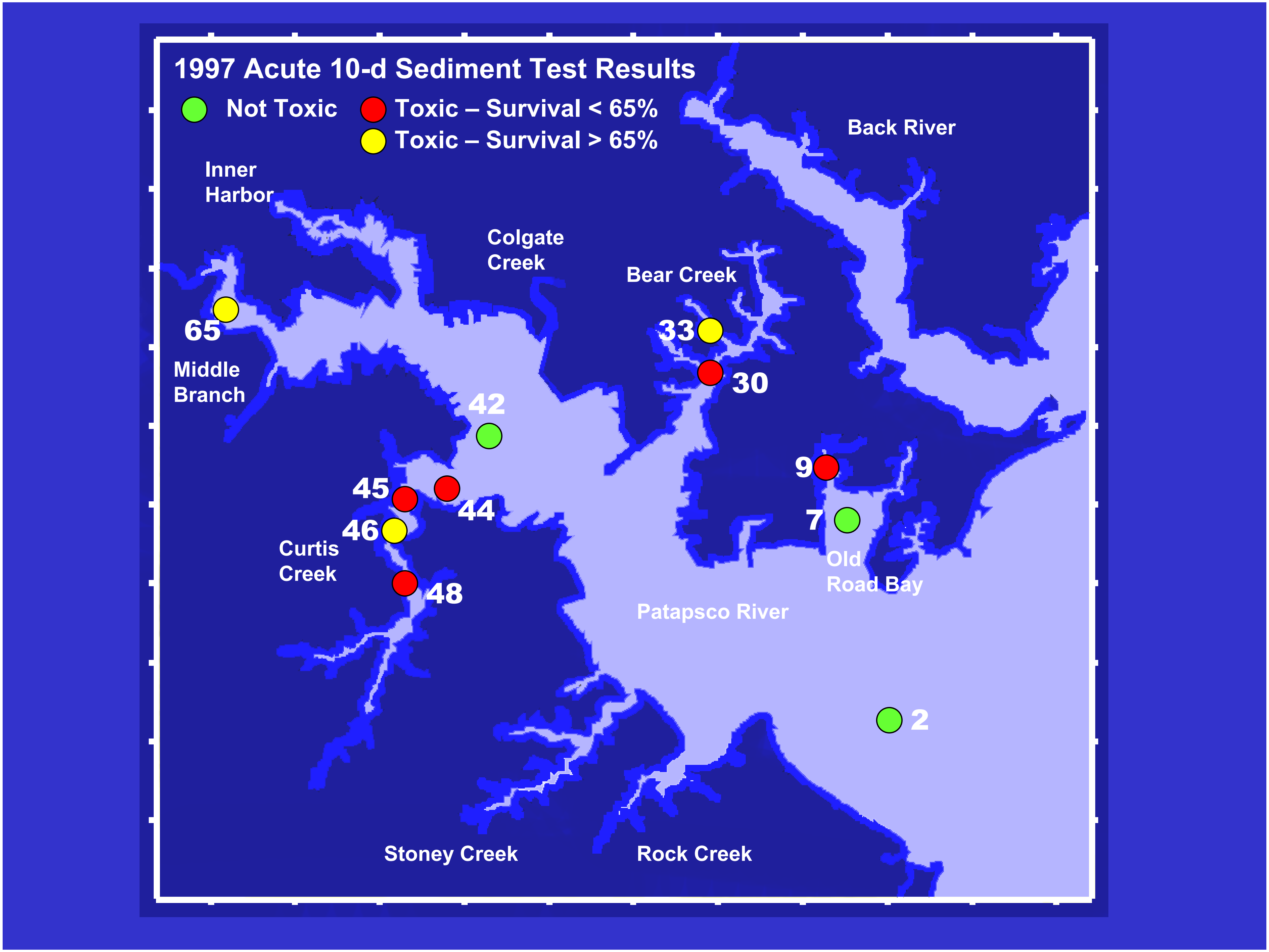
Performance criteria: Control survival ≥ 80%; Measurable growth & reproduction


1996 Acute 10-d Sediment Test Results
Not Toxic
Toxic – Survival < 65%
Toxic – Survival > 65%
Back River
Inner
Harbor
73
68
Colgate
Creek
Bear Creek
54
63
65
38
59
Middle
Branch
30
42
36
28
45
44
27
7
Curtis
Creek
Old
Road Bay
23
Patapsco River
49
Stoney
Creek
13
5
19
15
Rock Creek

Amphipod survival at sites that showed statistically significant acute toxicity in 1996

Site 28 (Bear Creek)	0%
Site 30 (Bear Creek)	49%
Site 38 (Colgate Creek)	55%
Site 54 (Lazeretto Point)	83%
Site 68 (Inner Harbor – Canton)	53%
Site 73 (Inner Harbor)	60%


Acute Toxicity (% survival)
100
50
0
0.1
1
10
100
1000
10000
100000
Amphipod density (no. per m sq.)
13
19
7
23
49
5
44
45
36
42
54
73
38
30
68
28


1997 Acute 10-d Sediment Test Results
Not Toxic
Toxic – Survival < 65%
Toxic – Survival > 65%
Inner Harbor
Colgate Creek
Bear Creek
Back River
65
Middle Branch
33
30
42
9
45
44
7
46
Curtis Creek
Old Road Bay
48
Patapsco River
2
Stoney Creek
Rock Creek

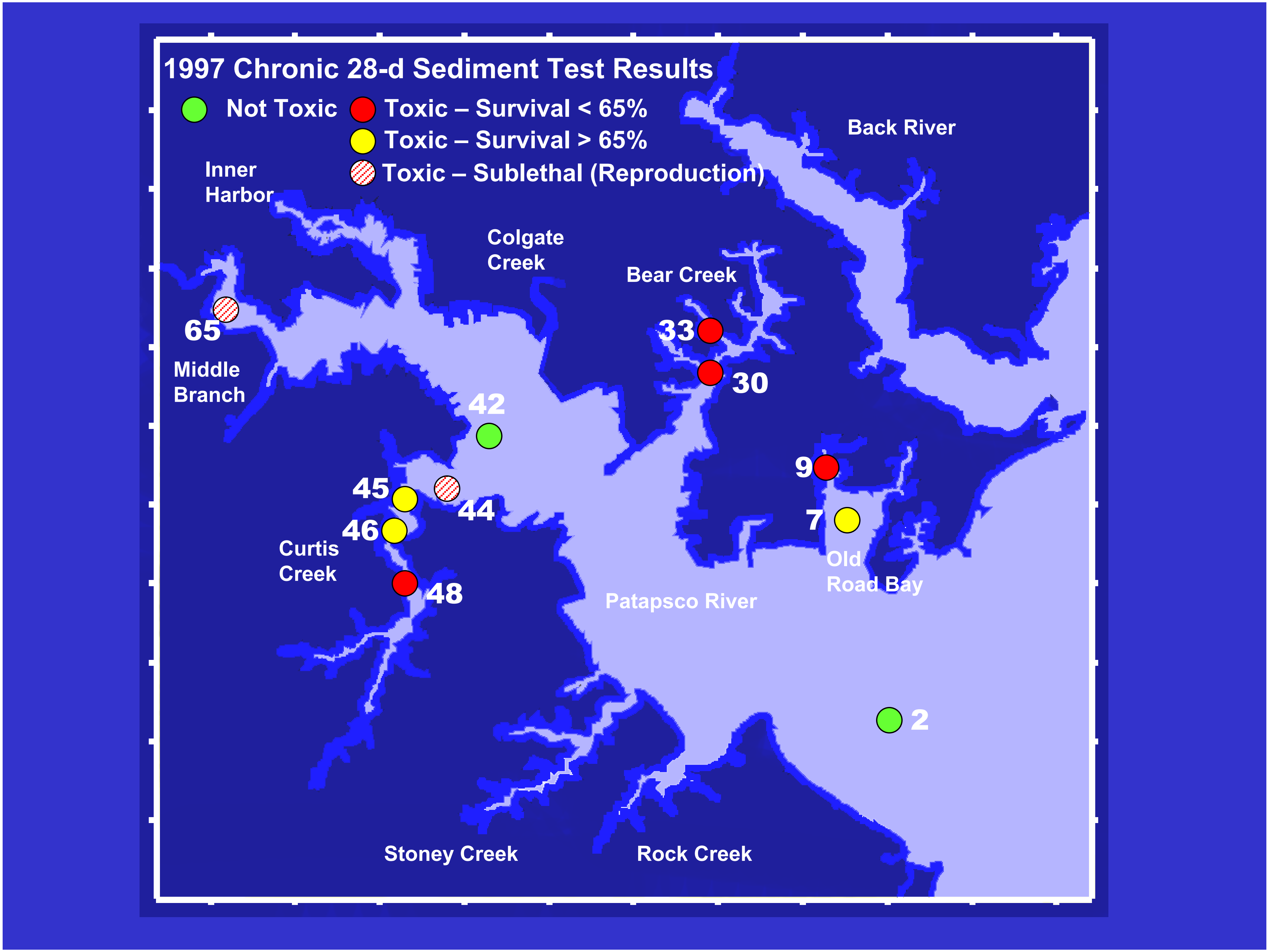
Amphipod survival at sites that showed statistically significant acute toxicity in 1997

		Survival - 96 Test when not toxic
BSM 9 (Old Road Bay)	10%	
BSM 30 (Bear Creek)	1%	49%
BSM 33 (Bear Creek)	66%	
BSM 44 (Curtis Bay)	51%	82%
BSM 45 (Curtis Bay)	47%	77%
BSM 46 (Curtis Bay)	68%	
BSM 48 (Curtis Bay)	52%	
BSM 65 (Middle Branch)	72%	91%

Benthic analyses of samples taken at the same time that the toxicity samples were taken showed that *L. plumulosus* was only found at BSM 2 and 7. These sites were two of the three sites found to be non toxic in the this 10-d acute test.

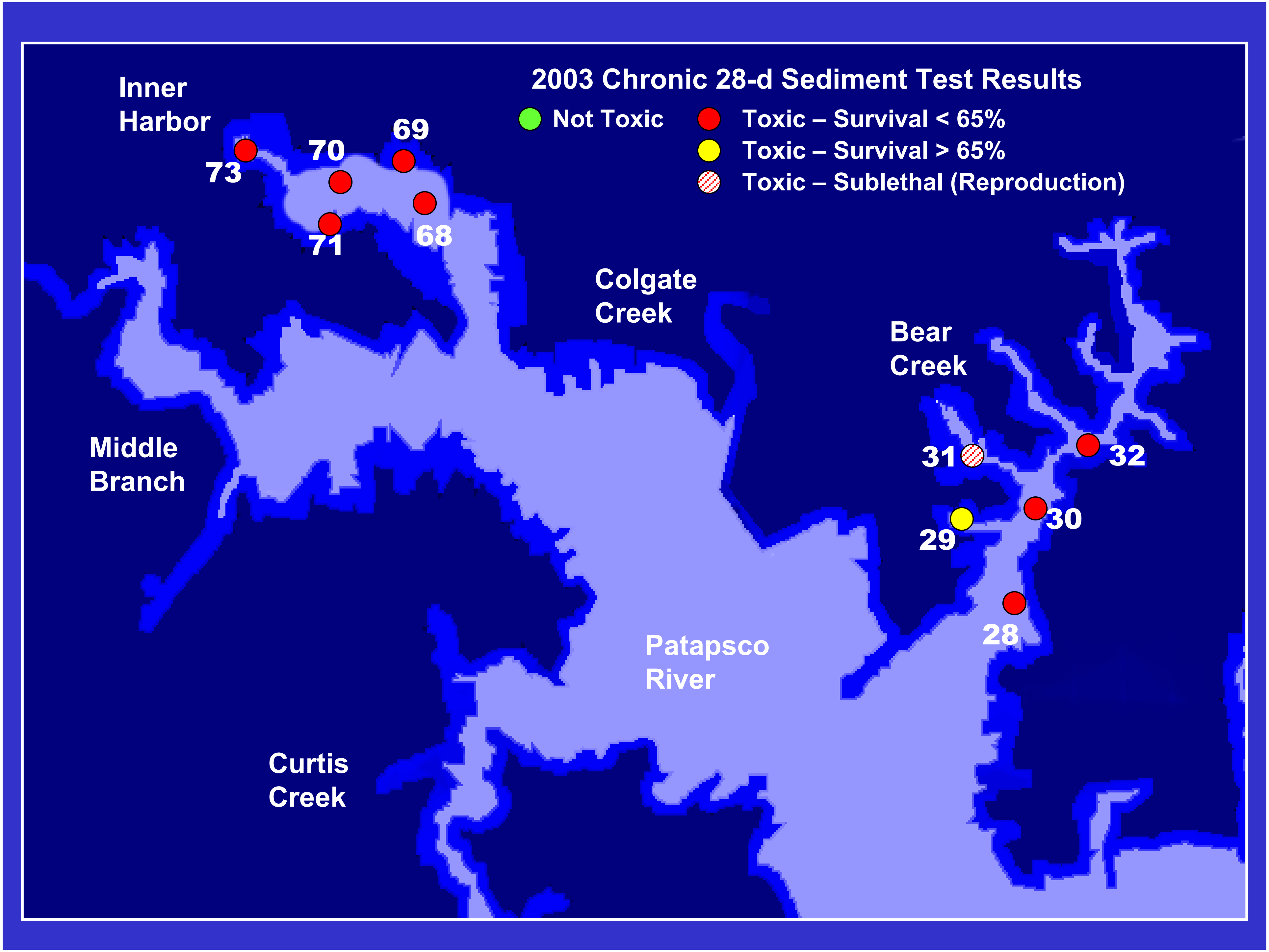
BSM 42 was the other site that was not acutely toxic. This site had no *L. plumulosus* this year but had significant numbers when sampled in 1996. Bad sample? Slightly different location?

There was also a good relationship with the B-IBI (Versar) and toxicity. Two of the three sites with the highest B-IBI scores were not acutely toxic.


1997 Chronic 28-d Sediment Test Results
Not Toxic
Toxic – Survival < 65%
Toxic – Survival > 65%
Toxic – Sublethal (Reproduction)
Inner Harbor
Colgate Creek
Bear Creek
Back River
65
Middle Branch
33
30
42
9
45
44
7
46
Curtis Creek
Old Road Bay
48
Patapsco River
2
Stoney Creek
Rock Creek

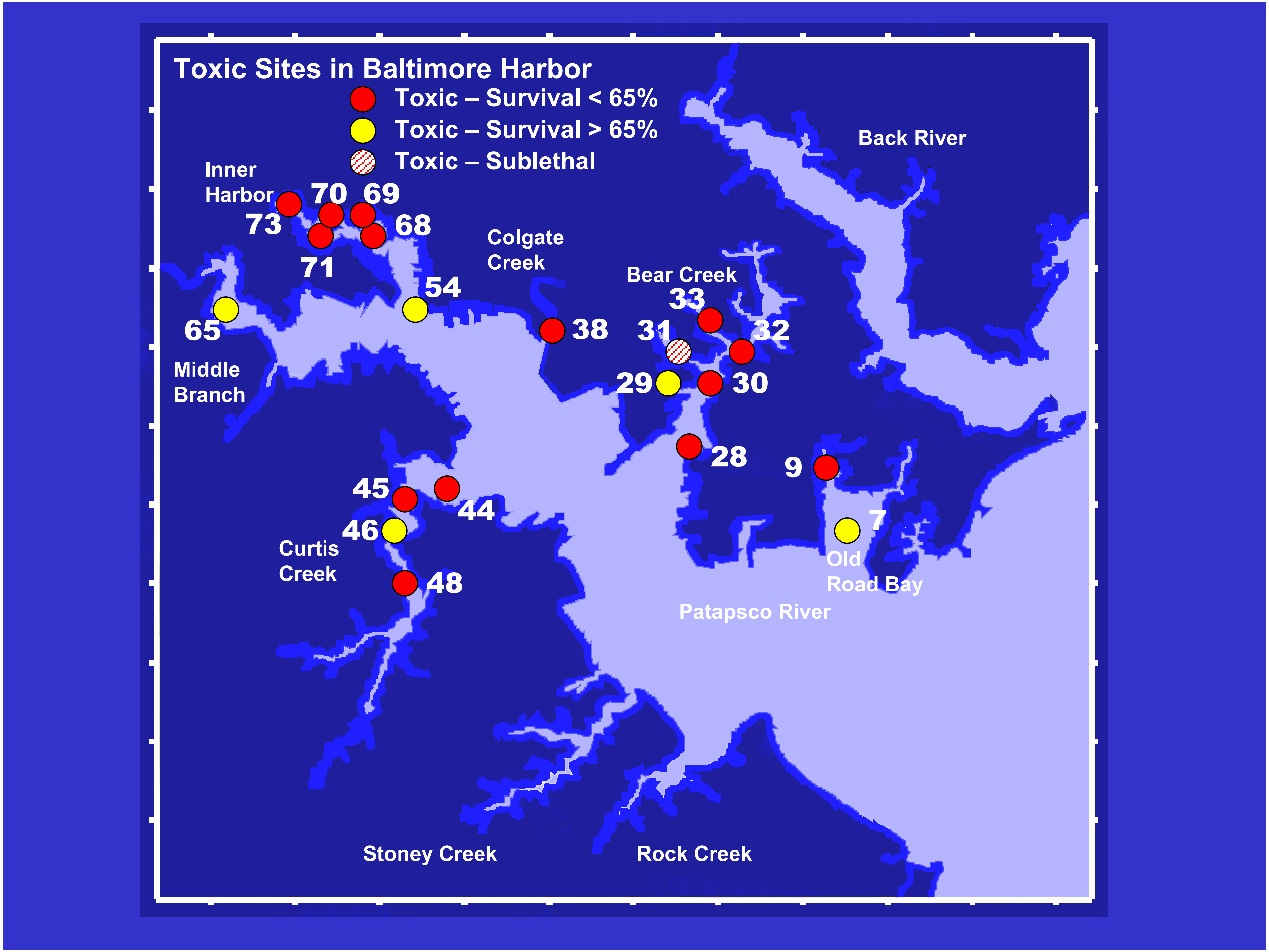
Amphipod data for sites that showed statistically significant chronic toxicity in 1997

BSM 7 (Old Road Bay)	77% Survival
BSM 9 (Old Road Bay)	58% Survival
BSM 30 (Bear Creek)	3% Survival
BSM 33 (Bear Creek)	39% Survival
BSM 44 (Curtis Bay)	Reduction in reproduction
BSM 45 (Curtis Bay)	68% Survival
BSM 46 (Curtis Bay)	80% Survival
BSM 48 (Curtis Bay)	55% Survival
BSM 65 (Middle Branch)	Reduction in reproduction


2003 Chronic 28-d Sediment Test Results
Not Toxic
Toxic – Survival < 65%
Toxic – Survival > 65%
Toxic – Sublethal (Reproduction)
Inner Harbor
73
70
69
71
68
Colgate Creek
Bear Creek
Middle Branch
31
32
30
29
28
Patapsco River
Curtis Creek

Amphipod data for sites that showed statistically significant chronic toxicity in 2003

BSM 28 (Bear Creek)	0%	Survival
BSM 29 (Bear Creek)	72%	Survival
BSM 30 (Bear Creek)	2%	Survival
BSM 31 (Bear Creek)	Reduction in reproduction	
BSM 32 (Bear Creek)	63%	Survival
BSM 68 (Inner Harbor)	61%	Survival
BSM 69 (Inner Harbor)	35%	Survival
BSM 70 (Inner Harbor)	9%	Survival
BSM 71 (Inner Harbor)	3%	Survival
BSM 73 (Inner Harbor)	55%	Survival


Toxic Sites in Baltimore Harbor
Toxic – Survival < 65%
Toxic – Survival > 65%
Toxic – Sublethal
Back River
Inner Harbor
70
69
73
68
71
Colgate Creek
Bear Creek
54
33
65
38
31
32
Middle Branch
29
30
28
9
45
44
46
7
Curtis Creek
Old Road Bay
48
Patapsco River
Stoney Creek
Rock Creek

Possible Causes of Toxicity

Effects Range Medium (Long et al., 1995)

Compare levels of contaminants at sites with the ERM values. ERMs are concentrations of contaminants that have been shown to cause an adverse effect of 50% in past whole sediment studies. The ERM quotient is the concentration of the contaminant at each site divided by it's ERM. These can be summed (SERM-Q) or averaged (MERM-Q) to get some feel for the level of contamination and the likelihood of adverse effects. If ERM exceedences are mostly organics or metals than toxicity could be due to those contaminants

From our 1996 and 1997 studies we concluded –

A significant relationship was observed between MERM-Q values and amphipod survival in these tests. Higher MERM-Q > toxicity.

ERM-Qs for metals were highest in Bear Creek (BSM 28-32) and ERM-Qs Values for PAHs were highest in the Inner Harbor stations (BSM 60s and 70s) indicating these could have been the causes of the toxicity seen at these stations.

3 PAH model developed by Swartz et al. (1995)

Toxic Units calculated for each of 13 PAHs by dividing predicted interstitial conc. by the predicted 10-d LC50. LC50s of the 13 PAHs presented by Swartz. Toxicity assumed to be additive. Swartz indicated a 3 TU of greater than 0.186 could indicate toxicity due to PAH.

From our 1996 and 1997 studies we concluded –

BSM 73 in the Inner Harbor had 3 TU of 0.217, therefore PAHs <u>could</u> have been problem there. All others had 3 TU < 0.186. BSM 68 had second highest 3 TU (0.114). Concentrations of PCBs and metals also very high at these Inner Harbor stations. These <u>could</u> also have contributed to toxicity.

The low 3 TU in Bear Creek samples <u>suggests</u> that PAHs are not a problem in that tributary.

AVS-SEM method for cationic metals of DiToro et al. (1992) - Acid Volatile Sulfide (AVS) - Simultaneously Extractable Metals (SEM)

If AVS-SEM is positive there should be little or no cationic metals bioavailable in pore water and the sediment should not be toxic (Ag, Cd, Cu, Hg, Ni, Pb, Sn and Zn). Excess sulfides form metal sulfides which are not bioavailable from the pore water.

From our 1996 and 1997 studies we concluded –

At all of the sites in this study that showed significant toxicity (>20% of control) the AVS-SEM values were positive indicating that pore water metals should not be the cause of toxicity.

Especially dramatic in Bear Creek where both metals and sulfides were very high. AVS-SEM + 100 to + 300. If a negative number is necessary for pore water toxicity than pore water metals exposure should not be the problem here.

As mentioned previously the 3 TU approach also indicates that PAHs should not be a problem. Confusing, at the least!

Conclusions

There is a lot of sediment toxicity in Baltimore Harbor.

There is very little consensus as to the causes of this toxicity.

In fact, there is some research (Lee et al., 2000) that indicates pore water bioavailability of metals may not be as important in sediments as sediment ingestion, therefore pore water tests to determine cause of toxicity are probably not appropriate.

Efforts to determine cause of toxicity through traditional methods such as ERMs, 3 TU for PAHs, and AVS-SEM for metals produce confusing and sometimes conflicting results.

Ongoing efforts to develop toxicity identification evaluation (TIE) procedures for sediments, especially whole sediment TIEs, should enhance our understanding of the chemical causes of toxicity in sediments. These whole sediment TIE procedures have recently been published/submitted for publication in journals by Ho et al. (2003) and Burgess et al. (2000, 2003) of the USEPA Narragansett Laboratory.